QE90S383I91999c.1

GEOLOGY OF THE WATERSHEDS

QE
90
S383.I9
1999
c.1
LIBRARY

SANTA CLARA VALLEY WATER DISTRICT
LIBRARY
5750 ALMADEN EXPRESSWAY
SAN JOSE, CALIFORNIA 95118

THIS DOCUMENT IS PREPARED FOR

COMPREHENSIVE RESERVOIR WATERSHED MANAGEMENT STUDY

SANTA CLARA VALLEY WATER DISTRICT

by

Thomas I. Iwamura
Engineering Geologist

Assisted by

Ellen C. Fostersmith
Assistant Engineering Geologist

REVISED APRIL 1999
(supersedes previous undated version)

TABLE OF CONTENTS

Page

INTRODUCTION 1

GEOLOGY AND WATER QUALITY 2
    BASIC PRINCIPLES 2
    EFFECT OF SEASONAL FLOWS 3
    EFFECTS OF RESERVOIRS 3
    TURBIDITY 4
    METALS AND PESTICIDES 4

REGIONAL GEOLOGY 5
    STRATIGRAPHY 5
        Franciscan Group 5
        Cretaceous Sedimentary Formations 6
        Tertiary Sedimentary Formations 7
        Tertiary Volcanics 8
        Santa Clara Formation 8
        Old Alluvium 9
        Young Alluvium 10
    STRUCTURAL GEOLOGY 10

COYOTE CREEK 12

STEVENS CREEK 17

LOS GATOS CREEK ABOVE LEXINGTON RESERVOIR 19

LOS GATOS CREEK FROM LEXINGTON RESERVOIR TO VASONA RESERVOIR 22

GUADALUPE CREEK 24

ALAMITOS CREEK 26

ARROYO CALERO 29

LLAGAS CREEK 32

UVAS CREEK 34

BIBLIOGRAPHY 36

INTRODUCTION

This section under Geology and Water Quality describes the geologic settings of the watershed and its relationship to the physical and mineral quality characteristics of the drainage runoff. It will also describe some of the basic principles or basis for mineral quality characterization and describe some aspects of quality that are common to runoffs of all the drainages under discussion. The geologic discussion will be on a regional basis and on a local basis. The regional discussion will describe the geologic makeup of the Diablo Range and the Santa Cruz Mountains, discuss descriptions of the geologic formations, and the regional geologic structural features. Predominant mineral water type of the runoff for each of the formations will be presented, as based upon prevailing cations and anions as calculated on the basis of equivalents per million. These will be further discussed in the following text.

The description of the local geologic conditions will focus on the geologic setting of each of the individual watersheds discussed in this report. The focused discussion of each watershed will discuss the relative areal abundance of the various formations that underlay the watersheds. The section will also discuss any physical peculiarities and anthropogenic activities within the watersheds and the expected and measured mineral quality type water of the watershed.

The following watersheds are discussed:

- Coyote Creek drainage above Coyote and Anderson Reservoirs in the Diablo Range east of the valley areas of the county
- Stevens Creek drainage above Stevens Creek Reservoir in the Santa Cruz Mountains west of Santa Clara Valley
- Los Gatos Creek drainage above Lexington Reservoir in the Santa Cruz Mountains and Vasona Reservoir in Santa Clara Valley
- Guadalupe Creek drainage above Guadalupe Reservoir in the Santa Cruz Mountains
- Alamitos Creek drainage above Almaden Reservoir in the Santa Cruz Mountains
- Arroyo Calero drainage above Calero Reservoir in the Santa Cruz Mountains
- Llagas Creek drainage above Chesbro Reservoir in the Santa Cruz Mountains west of Coyote Valley and Llagas Basin
- Uvas Creek drainage above Uvas Reservoir in the Santa Cruz Mountains west of the Llagas Basin

GEOLOGY AND WATER QUALITY

BASIC PRINCIPLES

As rain falls to the earth, the essentially pure water would dissolve small amounts of gases and upon contact with the formations, it would react with the rock forming minerals and dissolves salts into its content. Among the most common cations that dissolve in water include calcium, magnesium, sodium, and potassium and the anions include bicarbonate, sulfate, and chloride. Though individually these do not have an advisory maximum contaminant level (MCL), they collectively constitute almost all the total dissolved solids (TDS) content of the water, usually expressed in milligrams per liter (mg/L). The advisory for drinking water is below 500 mg/L as desirable and up to 1,000 mg/L permitted.

The common cations and anions listed above form the basis of the mineral typing of waters. Because the different ions have different molecular weights, different combining properties as based upon its valence and that the cations and anions must balance, the individual constituents are converted from mg/L as determined by laboratory analyses to equivalents/liter (epm) or milligram-equivalent per kilogram. Epm is determined by multiplying the mg/L by the valence of the constituent and divided by the molecular weight:

$$\text{epm} = \frac{\text{mg/L x valence}}{\text{molecular weight}}$$

As based upon the equivalent weight, the naming of the mineral type would be based upon the predominant cation and anion. The mineral type would be a calcium bicarbonate should calcium exceed 50 percent of the total cation equivalents and bicarbonate exceed 50 percent of the total anions. If the particular cation or anion do not exceed 50 percent, the mineral type would be based upon the most predominant cations and anions. Thus waters can be typed calcium-magnesium bicarbonate, calcium bicarbonate-chloride, or calcium-magnesium bicarbonate-chloride or the like. Should the cations or anions be about the same in equivalents, the mineral type would be classed a mixed bicarbonate type, calcium mixed type, or a mixed mineral type depending if either cations or anions are about the same equivalent or as in the last example if all the constituents are about the same in equivalent weight.

This nomenclature is established because runoffs of certain formation and/or watershed would have a particular water type resulting in the runoffs. A consistency can be established and evaluated in the investigation of mineral quality of waters, even when different water types from different watersheds are mixed. Should the resulting mineral type from a watershed or upon mixing be inconsistent, an anomaly has to be considered and investigated. Such anomalies could be caused by unforeseen geochemical processes (water reacting with formation materials), pollution, unidentified inputs, etc.

The mineral quality or usability of waters can also be affected by other constituents, usually objectionable in much smaller quantities. These might include elevated levels of nitrate, chloride, sulfate, anthropogenic (man-made) chemicals, and heavy metals. Certain physical properties also are included in the measures of the quality of water, particularly for drinking water. These include turbidity, color, taste, and odor. For more specialized use of waters, other parameters have to be measured to determine water quality. These might include additional nutrient loading, boron, and when the TDSs are elevated, the mineral water type might affect its use, particularly if the sodium content is high, its use for agriculture might be limited.

Hydrothermal alteration of rocks would allow accelerated weathering and have the potential to increase the dissolved mineral loading on runoffs. Such suggestions of hydrothermal alterations are in bedrock areas that show deep and high degree of weathering, mineralized springs, and the occurrence of precious metal deposits. These will be discussed in the more focused discussions of the individual watersheds.

Biologic and bacterial effects are discussed in other portions of the Comprehensive Reservoir Watershed Management Project (CRWMP) report.

EFFECT OF SEASONAL FLOWS

Dissolved mineral concentration of water is generally expressed in TDS or can be estimated by using a percentage of the electrical conductivity value expressed as specific electrical conductance in microSiemens/centimeter at 25°C. In runoff waters, the dissolved mineral concentration varies widely, largely depending upon the rate of runoff flow. High flows of rapid rainfall runoff would contain low levels of mineral salts due to high amounts of dilution while low flows in streams would contain a much higher dissolved salt content. The higher salts are due to lower dilution and the result of a higher percentage of the flow being contributed by groundwater versus overland flows during low flows from the watershed. Groundwater usually carries a higher mineral content than surface water. When streams are sampled, a measurement, or an estimate, of the flow should be made; otherwise the dissolved mineral content by itself would not have the full meaning of the analyses.

When a sufficient number of analyses and flow data are compiled, a rating curve could be plotted for each unimpeded portion of the watershed (exclude reservoir affected areas). This could be accomplished by graphically plotting the TDSs content in mg/L on the ordinate against logarithmic plotting of the flow in cubic feet per second (cfs) on the abscissa. This plot for each watershed would characterize the TDS/flow relationship, the differences of their relationship between the different watersheds, and the sensitivity of the watersheds. When an individual plot deviates from the majority curve, a closer review of this anomaly and the processes might be warranted.

EFFECTS OF RESERVOIRS

Impoundment of flows in large reservoirs would have the tendency to average out the mineral quality of those lower TDSs at high flows and the higher TDSs at low flows. However, the averaging would have a bias toward the huge volumes of the high winter flows, leading to a general water with less mineral salts. During the impoundment, much of the turbidity that is washed in with the high flows would settle out. Colder waters would also settle to the bottom of the reservoir.

Several of the reservoirs, such as Anderson and Calero, might also be mixed with imported water from the San Felipe Project. For surface water, the resulting quality would amount to a simple admixture of respective quality and volumes involved.

In certain reservoirs, particularly those with long stagnation periods, the quality might deteriorate due to eutrophication, stratification of salt concentrations and/or temperature, and oxygen depletion. Due to the extremely high rate of seasonal turnover in the District's reservoirs, these adverse effects have not been noted.

TURBIDITY

Large areas of the watersheds exhibit a high degree of rock weathering and deep soil development. These properties make them susceptible to erosion and mass wasting which contribute to turbidity of the runoffs. Turbidity that is yielded from the watershed is among the most problematic of the water quality parameters during high runoff stages.

A high degree of rock weathering and soil formation resulted due to the intense diastrophism that caused the mountain making forces within the earth and to the general softness of the younger sedimentary formations. A high degree of differential erosion, landsliding, and mass wasting are generally common in all the watersheds studied. Even though most of the watersheds are covered by grassy sod and varying amounts of brush and trees, certain areas along the stream channels, certain steep areas, and deep soil areas where high velocity flows are channeled are susceptible to erosion and sediment production to the streams.

During seasonal low-flow stages when a high percentage of the flow is contributed by effluent groundwater seepage into the stream, the flow generally runs clear. Certain present land use such as cattle grazing along the streams, mining activities, and unregulated quarrying may disturb the clearness of the stream flow. Recreational activities can also contribute varying amounts of turbidity to the runoff, depending upon the type of recreational activity and how it is regulated.

Future land use activities that might alter natural vegetative cover and land grading would contribute additional amounts of sediment yield from the drainage area to the flows. Such land use activities might include off road motorized recreational activities; road construction; logging; quarrying of rock, sand, and gravel; mining; and landfilling. Some impacts might be temporary and confined to the time of initiation provided remedial mitigations are quickly instituted and some will persist.

METALS AND PESTICIDES

Dissolved metals and pesticides have never been a problem of watershed runoffs. This was further confirmed by tests of runoff water at sample points downstream of the reservoirs which also include runoffs from the urban valley floor areas (Sylvester, Marc A., 1986). These test results indicated the highest levels of metals and pesticides, though still below MCL, occurred during the periods of high runoffs when normally there should occur the highest dilution. It can be concluded that these constituents were, therefore, carried in the turbidity rather than being dissolved in the runoff water.

Certain metals impact, such as mercury, will be discussed under the individual drainages that were impacted.

REGIONAL GEOLOGY

Santa Clara County is located in central coast ranges of California, inland from the Pacific Ocean, and south of San Francisco Bay. The coast ranges are a series of northwesterly trending mountain ranges along the California coastline. The southerly extension of San Francisco Bay is the Santa Clara Valley, an alluvial intermontáne valley that narrows to the southeast and connects to Coyote Valley, which in turn connects to the Llagas Basin at its southern boundary. These alluvial fill basin cuts northwesterly across the county. These valleys are flanked by the Santa Cruz Mountains on the southwest and by the Diablo Range on the northeast. The mountainous areas comprise about three quarters of the county.

The drainage area above Coyote and Anderson Reservoirs is located in the Diablo Range and the other drainage areas of this study are in the Santa Cruz Mountains.

STRATIGRAPHY

Within the county, similar formations form the Santa Cruz Mountains and the Diablo Range and they underlay the valley fill areas of the county. The discussion of the formations will start with the oldest formation to the youngest. These are divided into two broad groups: (1) Mesozoic formations which date back to about 160 million years ago to 70 million years ago and (2) the younger Cenozoic formations which range from about 70 million years to the present. The Mesozoic members include the Franciscan Group and its serpentine member and Cretaceous sedimentary formations. The Cenozoic members include Tertiary volcanics, Tertiary sedimentary formations, Santa Clara formation, old alluvium, and young alluvium. A general description of the formations will be discussed here under regional geology. Any peculiarities or variations such as association with mineral deposits, quarry rock, hot springs, local landsliding, and weathering will be discussed under the discussions of individual drainages.

Franciscan Group

The Franciscan Group is a complex mixture of rock units sheared, contorted, and faulted by high earth pressures and relatively low earth temperature since burial. These suggest a very active tectonic history of the group since deposition. The lower section of the unit is composed largely of submarine deposited volcanic rocks, serpentine, and silica carbonate (collectively often referred to as ophiolites). These are highly altered remnants of volcanic arc rock deposits as part of the regional collision of tectonic plates. The group also consists of marine deposited lithic sandstone, shale, and chert, some of which have metamorphosed to schists. A characteristic broad zone of this group is referred to as the Franciscan melange unit, composed of highly sheared and discontinuous units of sandstone, shale with large blocks of schists, serpentine, metavolcanics, chert, and some limestone. The pervasive shearing, contortion, and discontinuous nature of the rocks indicate a long period of diastrophism as these rock materials were deposited in an east dipping submarine subduction zone and had been subjected to 140 million years of continuous subductive forces. These aggregations which forms a large part of the coast ranges now have been accreted to the western continental land mass. Due to the highly sheared nature of the units within this group, the rock materials are susceptible to weathing, variable soil development, landsliding, and erosion which can contribute to high turbidity during high flows and to sedimentation of channels and reservoirs.

Though most of the large bodies of serpentine within the Franciscan Group occur downstream of the reservoirs, mostly along the southeastern boundaries of the Santa Clara Valley in the Diablo Range, smaller but significant bodies of serpentine have pervasively intruded the unit throughout (in small unmappable units for small scale maps). However, it is the serpentine unit that controls the mineral quality of waters that drain the Franciscan Group terrain. Runoffs are usually a magnesium bicarbonate type water, as the serpentine has a high magnesium content. Soils that have developed over weathered serpentine are toxic to most plants because of the high magnesium content as the plants would have difficulty in absorbing the calcium that they need. However, there are a few characteristic species that have adapted and are the exceptions, such as a type of ceanothus in the foothill areas referred to as ceanothus ferrisae, or more commonly known as Coyote ceanothus. Heavy metals such as mercury, chromium, and nickel are also present that may present problems. Waters draining serpentine often leave white evaporation lines along the pool edges that are represented by the mineral magnesite which is a magnesium carbonate. In some occurrences of magnesite when they filled in fractures to form thick veins, they were formerly mined in the high area of the Diablo Range at the border with Stanislaus County.

Several significant mercury mines and numerous mercury prospects are located within the serpentine associated with silica carbonate rock throughout the coast ranges of California. Silica carbonate is a hard rock that has the appearance of quartz vein.

Asbestos is formed from the recrystallization of sheared serpentine. Asbestos fiber counts of water samples from some the District's reservoirs had been noted.

Limestone mining operation for portland cement occurs within the Calera Limestone member of the Franciscan Group within the Permanente Creek drainage.

Small manganese deposits associated with Franciscan chert deposits (layered siliceous rock precipitated in a shallow marine setting, associated with ancient volcanic activities) have been noted in the Upper Penitencia Creek drainage area.

There are also localized crush rock quarrying operations at various locations within the Franciscan Group, mostly of the black greenstone (metavolcanic rock) member. One such quarry is located at Anderson Dam. The rockfill section of the dam was quarried here.

Cretaceous Sedimentary Formations

The Cretaceous sedimentary formations, also referred to as the Great Valley Sequence, consist of regularly-bedded series of micaceous sandstone, siltstone, and shale with locally thick layers of conglomerate. These were deposited in a marine environment in front of the westward advancing North American continent between about 136 to 65 million years ago. As the continent advanced westward, these marine deposits were accreted to the advancing craton and were thrusted over the Franciscan Group which were previously deposited in the marine subduction zone. The subduction zone formed the boundary of the Pacific plate and the North American continent. Today in Santa Clara County, only erosional remnants of the Cretaceous formations occur. These occur as a continuous northwesterly band in the south central portion of the county east of Coyote Valley and the Llagas Basin. Discontinuous bands occur along the western foothills of the Diablo Range east of Santa Clara Valley and along the western edge of the county in the Santa Cruz Mountains.

Individual Cretaceous formations include the Berryessa formation, Chico formation, Oakland conglomerate, and Del Valle formation.

The siltstone and shale have a tendency to weather and rarely show rock outcroppings to the surface except in downward eroding canyon areas. The hardest units are the sandstone and conglomerate and even these tend to weather. The Cretaceous terrain is often covered by grassy sod and trees on the hillsides. Where they occur, the boldest rock outcroppings tends to be the conglomerate member, particularly in certain canyon areas.

As no igneous activity occurred within these formations, little or no mineralization have taken place in these rocks.

Mineral quality of runoffs from the Cretaceous terrain can be variable, but would usually expected to be a calcium bicarbonate type water. Deep-seated connate water springs from this marine formation can be expected to be salty but the concentration can be moderated by mixing with meteoric (surface) water as it rises to the surface.

Tertiary Sedimentary Formations

After the Franciscan Group and Cretaceous sedimentary formations had been accreted to the westward advancing North American continent, and as mountain-making processes continued, certain areas became depressed and became inland marine waterways and coastal embayments. It was in these depressed marine basins that the Tertiary sedimentary formations were deposited. These deposits consists of often fossiliferous sandstone, shale, siliceous shales, chert, and some conglomerate and minor limestone. These deposits have been variously divided into the San Lorenzo, Butano, Vaqueros, Temblor, Monterey, Briones, and the Purisima formations.

Toward the end of the Tertiary period, the area began to rise due to acceleration of mountain-making processes and the inland seas and embayments receded. Some of the late Tertiary formations which were mostly marine deposited have their upper portions deposited as subaerial fluvial deposits. These include the Purisima formation and, in adjacent counties, the Santa Margarita formation.

The general distribution of Tertiary sedimentary formations within the county occur as discontinuous, northwest trending slivers of bedded formations along both east and west sides of the valley areas and along the upper crestline of the Santa Cruz Mountains.

The meager oil and gas deposits in the county are hosted in the Tertiary sedimentary formations. The two defined oil fields are the Sargent in a downfaulted block between the San Andreas and the Sargent faults in the southwestern portion of the county and Moody Gulch above Lexington Reservoir. Though these fields are generally inactive today, they have the potential to produce brines for disposal if or when the fields become active again.

The chert (siliceous bedded rock) in the Monterey formation is quarried for roadfill, as it can be hard and durable.

Runoffs are generally expected to be similar in mineral character as those from the Cretaceous sedimentary rocks but in some rock units, particularly of the organic, siliceous marine shales, a higher sulfate content would be expected. Sulfates may also be higher in some of the continental tertiary units should they contain secondary sulfate minerals, chiefly gypsum ($CaSO_4\,2H_2O$). The presence of chert in the Monterey formation may contribute trace amounts of manganese to the runoffs.

In Santa Barbara and Ventura Counties, certain tertiary formations, including the Monterey formation which also occurs in Santa Clara County, contained soil gas with radon at statistically higher levels above background than other formation. How this would be related to runoffs from these formations is uncertain. Whether the Monterey formation in Santa Clara County would have the same soil gas anomaly is also not known.

Tertiary Volcanics

Tertiary volcanic rocks occur as relatively small deposits of bedded volcanic flows, ash deposits, or as shallow intrusive igneous rocks. Their compositions range from basalt such as the Page Mill basalts to rhyolites such as the Alum Rock rhyolite. These also occur as small bodies of diabase or other volcanic rock types in the southeastern portion of the county. Because of their hardness and durability, basalts and rhyolite have been quarried for road fill.

In the Alum Rock area (not in the study area), hot springs discharge mineralized waters into the stream, though today the apparent flows are very small as compared to past decades. The smell of rotten eggs indicates hydrogen sulfide gas is associated with these springs. Often higher metals content are also associated with hot springs water. The low levels of boron found in the groundwater basin adjacent and downstream areas are though to be from the hot springs. In the southern part of the Llagas Basin, low levels of boron also occur. These may be from runoff from the San Juan volcanics which occur as a large deposit in the Diablo Range east of Hollister.

Normally, runoffs from volcanic rock, particularly younger volcanic rock, would contain a higher silica content than runoffs from other rock units.

Santa Clara Formation

The Santa Clara formation is a subaerially deposited fluvial, unconsolidated to lightly consolidated unit of bedded conglomerate, sandstone, siltstone, and mudstone. These were deposited during the late Tertiary period through the Pleistocene epoch of the Quaternary period. This interval generally spans from about 2 million years to 10,000 years ago. This was a period of continued uplift and mountain building in the Coast Ranges. The uplift had rejuvenated streams and huge gravel deposits were laid down in the valleys. In Santa Clara County, these are deposits which are adjacent to the valley floor and which dip beneath the young alluvium of the valley floor and are referred to as the Santa Clara formation. Those that were deposited along the east side of Coyote Valley and the Llagas Basin were referred to as the Packwood formation or Packwood gravels. For the District's study purposes, the Packwood formation is lumped into the

Santa Clara formation. Equivalent deposits in adjacent counties include the Livermore gravels and San Benito gravels.

The Santa Clara formation also contain a substantial amount of compacted siltstone and claystone. In the southern portion along and adjacent to the east side of Coyote Valley and Llagas Basin, a volcanic layer is intercalated within the alluvial sedimentary beds. The volcanic outcropping can be noted most vividly north of Anderson Dam.

The Santa Clara formation can be distinguished from younger alluvial deposits by its being broadly folded, but sometimes with dips of beds as high as 70° from the horizontal. The younger formations are undeformed. The Santa Clara formation is considered to be in-part water bearing. The portion that outcrops above the edges of the valley are generally considered to be nonwater bearing, though it may provide meager quantities to domestic wells located in some of the canyon areas. Stevens Creek Dam and Reservoir are founded on the Santa Clara formation with no discernable leakage through the formation. The portion of the formation that is considered to be water bearing is that which dips beneath the younger alluvial deposits in the large valley areas of the county.

Because of the general softness of the members of this formation, rock outcroppings are rare except for some substantial outcropping of the conglomerate unit in some stream canyon areas. The gently-rounded terrain is covered by grassy sod and low elevation trees and brushes. The low foothills terrain east of Coyote Valley is often bare except for a grassy sod covering. Where the surface grassy sod covers have been disturbed, significant erosion can occur which could contribute substantial amounts of brown silts into the water courses and reservoirs. Sometimes, erosional gashes would begin on hillsides if the rainfall is intense and of long duration.

Gravel quarries for road fill and other purpose fill materials have been operated in this formation. Due to the high clay content of the gravels in the foothills, extensive washing would be required to be suitable for aggregate.

The mineral character of the runoffs from this formation is expected to be a calcium bicarbonate type. Significant turbidity can be expected during large storm events.

Old Alluvium

Within the drainages of the study area, the old alluvium occurs in small mountain valleys. It more predominantly occurs along the elevated edges of the main valley floors as terrace deposits or older abandoned alluvial areas. These alluvial units generally are areas where the stream is presently downcutting as the sediment yields from the drainages today are for less than in the most recent geologic past when the overall regional precipitation was much higher. These deposits are noted in the Los Gatos Creek drainage upstream of Vasona Dam.

This unit consists of unconsolidated gravel, sand, silt, and clay. This unit is considered to be water bearing and can provide domestic use groundwater to mountain valley residents and is an important water-bearing formation in the large valley areas. Surficially, it also has the appearance of the Santa Clara formation but by being relatively young, the unit is undeformed. These deposits range in age from about 1 million years to 8,000 years.

Runoff from this formation is expected to be a calcium bicarbonate type water. As runoffs recharge this unit, they would tend to pick up calcium. The original runoffs from the drainages dominated by the Franciscan Group would be a magnesium bicarbonate type. Infiltration and percolation through the old alluvium (and also through the young alluvium) would tend to become modified to a magnesium-calcium bicarbonate or to a calcium-magnesium bicarbonate type water through the process of base exchange.

Young Alluvium

Like the old alluvium, the young alluvium occurs as small limited deposits within the mountainous study area. However, it predominantly covers the large valley areas of the county. This unit, consisting of unconsolidated gravel, sand, silt, and clay, occurs where it is actively being accumulated at present. This unit is considered to be water bearing and can be an important source of groundwater in the mountain valley should it achieve a significant thickness and is an important water-bearing unit of the major groundwater basins of Santa Clara County. This unit ranges in age from about 10,000 years to the present.

The young alluvium deposits are the major source of aggregate materials in the county. They can be quarried for other fill material and in the past for making bricks from the sandy clay unit. The surficial portions of this unit are generally fertile and have better subsurface drainage characteristics than the old alluvium and Santa Clara formation. As a consequence, the young alluvium can support a variety of growth and crops.

Runoffs from the young alluvium, like of the old alluvium, are expected to be a calcium bicarbonate type water. Infiltrating waters would pick up calcium and if groundwater percolate through this unit for miles, the groundwater would eventually become a calcium bicarbonate type. In mountainous areas where organic materials have accumulated to form peat deposits in a swampland environment, effluent seepages into streams may contain higher levels of dissolved organic carbon, iron, and total phosphorus.

STRUCTURAL GEOLOGY

The structural geology of the area, like in the discussion of the stratigraphy, is a reflection of the geologic history. The Coast Ranges are dominated by northwest trending folded and faulted sedimentary formations ranging from the Jurassic period (160 million years ago) to the Pleistocene epoch (about 2 million to 10,000 years ago). These ranges were formed by uplift and mountain-making processes as the North American plate collided with the Pacific Ocean plate. Many of the faults that occur in the area are no longer active but there are also other significant and not so significant faults that are active. The more prominent of the active regional northwesterly trending faults include the San Andreas fault in the Santa Cruz Mountains and the Hayward and Calaveras faults in the Diablo Range. These major faults are strike-slip faults (lateral movement). They are the resultant of the westward moving of the North American plate overriding the sea floor spreading zone as it collided with and overrode the Pacific plate and resulting in an askewed translation of forces that cause the strike-slip movements.

As noted previously under stratigraphy, the Cretaceous sedimentary formations had been thrusted over the Franciscan Group. As a consequence, all contacts between these two units are fault contacts. Though for the most part, the faulting along the contacts is no longer active. Old faults and shear zones which are prevalent in the Franciscan Group and its serpentine member for the most part inactive today though more infrequently active faults still persists.

The major valley areas also trend northwesterly, continues northwesterly as San Francisco Bay. These are the result of an intermontáne structural depression, formed by the block being downfaulted to create the depression. The valley areas are now being filled by alluvial deposits washing in from the Santa Cruz Mountains and the Diablo Range. These alluvial deposits comprise the groundwater basins of Santa Clara County. In Santa Clara Valley, the maximum depth of the alluvial materials is in excess of 1,500 feet.

COYOTE CREEK

The Anderson/Coyote Reservoirs watershed is located in the Diablo Mountain Range, east of Santa Clara Valley, and is characterized by steep and mostly undeveloped hillsides covered with a mix of grassland, oak savannah, chaparral, and a scattering of pine stands.

The Anderson Reservoir and Coyote Reservoir dams are both located on Coyote Creek, with the Coyote dam and reservoir upstream of the Anderson Reservoir. Water released from Coyote Reservoir flows into Anderson Reservoir. There are nine major tributaries to Coyote Creek within the drainage area to these two reservoirs. Canada de los Osos, Hunting Hollow, Dexter Canyon, and Larios Canyon Creeks are within the Coyote Reservoir drainage area. Otis Canyon, Packwood, San Felipe, Las Animas, and Shingle Valley Creeks are tributaries to Anderson Reservoir. Runoff above the Coyote Dam accounts for about 75 percent of the total runoff for the entire Anderson/Coyote watershed.

Above Coyote Reservoir, Coyote Creek has a stream flow Gauging Station No. 77. Above Anderson Reservoir, Coyote Creek has a stream flow Gauging Station No. 12, Las Animas Creek has Station No. 56, and Packwood Creek has Station No. 57. These streams are gauged during the summer months because of downstream riparian rights.

Summary Precipitation Data for the Anderson/Coyote Watershed

Gauge Station (Period of Record)	**Average Annual Precipitation** (Inches)	**Maximum Annual Precipitation** (Inches)	**Minimum Annual Precipitation** (Inches)
Anderson Reservoir (11/50 to 6/95)	19.54	41.4 in 1983	5.8 in 1976
Coyote Reservoir (2/36 to 6/95)	20.25	37.4 in 1983	6.0 in 1976
Cow Ridge (11/77 to 6/95)	27.94	55.7 in 1983	15.4 in 1988
U.S. Army Corps of Engineers Park (3/61 to 6/95)	27.61	60.55 in 1980	9.9 in 1976

The Coyote Creek drainage upstream of Anderson Reservoir is oriented northwest, conforming to the northwesterly trend of the bedding of the bedrock formations and the major fault systems. From its northern headwater in the elevated portion of the Diablo Range east of the southern portion of Santa Clara Valley, Coyote Creek flows southeasterly to the confluence of Canada de los Osos where it turns west across the bedding and then northwesterly into Coyote Reservoir, an elongated northwesterly reservoir. The stream continues northwesterly below Coyote Dam into Anderson Reservoir at its southeast end. The area northwest of Anderson Reservoir is drained by Las Animas Creek which flows southeasterly from its drainage divide with San Felipe Creek. Just before entering the northwestern end of Anderson Reservoir, Las Animas Creek picks up the southeasterly flowing Shingle Valley Creek and San Felipe Creek tributaries.

As shown on the geologic map, Figure _____, the northeastern one-half of the drainage is underlain by the Franciscan Group with its serpentine member. This unit on its southwestern side is in contact with Tertiary sedimentary formations in the northern portion of the drainage and with the Cretaceous sedimentary formations in the southern portion. The contact is formed by the northwesterly trending Madrone Springs fault. The lower elevation mountains and foothills along the southwestern portion of the drainage, including much of the area beneath Anderson Reservoir and portions of Coyote Reservoir, is underlain by the Santa Clara formation. The bedrock formations beneath the Santa Clara formation occur at varying depths. Anderson Dam is founded in a canyon underlain by the Franciscan Group as the stream had cut through the Santa Clara formation into the Franciscan Group. A layer of volcanic flow and ash is intercataled in the sedimentary beds of the Santa Clara formation. A significant outcropping of these volcanics occurs just north of Anderson Dam.

Some shallow deposits of old and young alluvial sediments occur in some of the mountain valleys and bottoms of the reservoirs.

The general mineral quality of waters from the Coyote Creek watershed above Anderson Dam is dominated by calcium and magnesium among the cations and by bicarbonate among the anions. Contribution of calcium and bicarbonate are from all the formations while a large contribution of magnesium would be from the Franciscan Group, particularly from the serpentine member.

A water quality sampling station was established just upstream of Coyote Reservoir on Coyote Creek for the CRWMP. To date, the period of record is from January 1996 through June 1997. Mineral quality of runoffs ranged from a calcium bicarbonate to magnesium-calcium bicarbonate to a magnesium bicarbonate type ranging in TDS from 125 to 460 mg/L and pH holding in a narrow steady range from 7.8 to 8.1. These results are consistent with the geology of the drainage that is predominated by the Franciscan Group and its serpentine member. Though based on a limited number of analyses, it appears that calcium predominates over magnesium among the cations during periods of high, rapid runoff and magnesium during the low-flow periods when effluent groundwater accounts for a higher percentage of the overall flow. One high spike of chloride content was reported at 73 mg/L in the November 1996 sampling event. Chloride content is usually below 15 mg/L.

Mercury content was always reported to be below 0.2 micrograms per liter (μg/L).

Total organic carbon (TOC) ranged from 0.98 to 7.27 mg/L and dissolved organic carbon (DOC) ranged from 1.07 to 6.99 mg/L. The higher values for both TOC and DOC were during the periods of higher runoffs. TOC averaged 3.92 mg/L and DOC averaged 3.57 mg/L.

Another sampling station for the program was established at Coyote Dam with samples taken at a depth of 1 foot. The period of record extended from January 1996 through June 1997. Mineral quality ranged from a calcium bicarbonate to a calcium-magnesium bicarbonate type and the TDS ranged from 135 to 342 and the pH from 7.7 to 8.1. The narrowing of the mineral quality of the water and the TDS indicates the averaging or mixing of waters when stream flow is impounded in reservoir. In one analysis of sulfate content, a value of 106 mg/L was noted in the May 1996 sampling event; usually sulfate content is one-half of that value. At that time, the TDS was 177 mg/L and the high value was enough to change the mineral type to a calcium bicarbonate-sulfate for that event. Mercury content remained below 0.2 μg/L.

TOC ranged from 2.39 to 4.75 mg/L and DOC from 2.67 to 5.8. The TOC average remained about the same at 3.72 mg/L as compared to the upstream station, and the DOC rose a little to 4.13 mg/L as compared to the upstream station of 3.57 mg/L.

Principal drainage streams from the northern end of Anderson Reservoir are Las Animas Creek and its tributaries, Shingle Valley Creek and San Felipe Creek. Random samples in the winter and spring of 1975 indicate the waters of Las Animas Creek above San Felipe Creek to be a calcium-sodium bicarbonate type water (one sample) and with spring flow TDS of 83 and 165 mg/L (two samples). The pH range from 7.9 to 8.1 (six samples).

A short distance downstream, less than 1 mile, another sampling point was established on Las Animas Creek upstream from Shingle Valley Creek. The period of record was from February 1975 through April 1975. Drainage waters were noted to range from a calcium bicarbonate to a calcium-magnesium bicarbonate type with TDS ranging from 142 to 264 mg/L and the pH from 7.9 to 8.1. Mineral type of water appears generally consistent with geology of the watershed. Although the one sample above San Felipe Creek confluence in equivalents was noted to be calcium-sodium bicarbonate type, the TDS of this sample was very low, 83 mg/L, and the sodium content was only 9.8 mg/L. Hence, this disportionate rise in sodium equivalents is of little significance. The drainage above these two stations are underlain by equal amounts of Franciscan Group, Cretaceous sedimentary formations, tertiary sedimentary formations, and Santa Clara formations.

A series of samples were obtained from a station on Shingle Valley Creek above its confluence with Las Animas Creek. The period of record was from February 1975 through April of 1975. Drainage waters were noted to be a magnesium bicarbonate type water with TDS ranging from 239 to 344 mg/L and pH from 8.0 to 8.4. The upper portion of this watershed is underlain by the Franciscan Group and the lower portion by the Santa Clara formation. Nitrate was analyzed in three of the samples. All three were taken in the month of February 1975. These three indicate nitrate content of 4.6, 12.3, and 7.5 mg/L. These are anomalously high when normal contents are usually less than 3 mg/L for local surface water drainages.

Only partial mineral analyses of Anderson Reservoir are available. The period of record is from October 1974 to August 1975 for the partials. These indicate the TDS to range from 232 to 356 mg/L and pH from 7.8 to 8.4. Nitrate content was generally below 1 mg/L. Most of the waters that would be impounded in Anderson Reservoir would be from the Coyote Creek drainage entering from the south and lesser amounts from the north from northern drainage, mainly from Las Animas Creek and its tributaries, San Felipe Creek and Shingle Valley Creek. The proportionate mix of waters should result in a predominant calcium-magnesium bicarbonate type water of high quality.

More recently, the District's operation can consider storing a portion of the San Felipe Project's imported water into Anderson Reservoir to a certain maximum elevation. Many factors would have to be considered in such an operation. Time of inputs into the reservoir furthermore might be seasonal. During normal years, the amount of imported water into the reservoir might have little influence on the mineral quality of the reservoir, when such amount might be small. In some unusual years when local runoffs are small, leaving a large excess capacity for imported waters, the influence might be significant.

As imported waters, which originates in northern watersheds of California, San Felipe waters would have to pass through the delta area of the Sacramento-San Joaquin River and the final mineral type of water could be quite variable. Such resulting mineral types may range from a sodium chloride, sodium-calcium mixed ion to a sodium-calcium chloride-bicarbonate type. TDS is expected to be mostly below 300 mg/L and pH from 7 to 8. The high equivalents of sodium is from the mixing with incurring salt waters from San Francisco Bay as the project waters pass through the delta area. TOC and DOC were not measured but could be significantly elevated as the waters pass through the delta. TOC and DOC at significant levels can affect complexation of metals (remove by precipitation).

Three notable mineral springs occur within the drainage. These springs are along or in proximity of the Madrone Springs fault. All of these springs are tributary to Upper Coyote Creek, well upstream of Coyote Reservoir. These springs include Gilroy Hot Springs, Madrone Springs, and Coe Springs.

Gilroy Hot Springs occurs in a flat terraced area above the west side of the south flowing Coyote Creek at that reach, about 3 miles upstream of the confluence of Canada de los Osos. It is in Section 36, Tract G of Township 9 south, 4 east, Mount Diablo Base and Meridian (MDB&M). Observed temperatures ranged from about 105°F to 110°F and yields about 3½ gallons per minute. Its TDS is about 1,200 mg/L. Its mineral character varies, as does its yield and temperature, from a sodium chloride type to a sodium bicarbonate type to a sodium-magnesium bicarbonate type. These variations indicate that the water is a mix of meteoric water and connate water (entrapped mineralized formation water) at different ratios. Heavy metals content were low but boron was noted to be significantly high in one analyses at 17 mg/L.

Madrone Springs occur on the Soda Springs Canyon tributary to Coyote Creek about 8 miles upstream of the confluence of Canada de los Osos into Coyote Creek. It is in Section 10, Tract K, Township 9 south and 4 east, MDB&M. The spring issues from alluvium at a temperature of 54°F and the waters are mineralized slightly. The mineral character is a calcium bicarbonate type. Nearby seeps have been called "arsenic" and "iron" springs but did not appear notably mineralized.

Coe Springs is located about 2½ miles northwest of Madrone Springs on the Coe Ranch. It is in Tract N of Section 33 of Township 8 south and 4 east, MDB&M. The springs issue from Franciscan Group bedrock and the water is used for cattle watering. The waters were noted to be carbonated. Small amounts of iron-stained and cemented gravels had been formed along the creek below. Analysis indicated the waters to be a magnesium bicarbonate type with some mineralization.

Due to the low discharge of these springs, spring water would have virtually no affect on the overall water quality of the drainage system. Their influence might be only local during low flows of their tributaries.

Two minor mining prospects are noted in the watershed. The first is a maganese prospect known as the Pine Ridge Mine, located atop of Pine Ridge near the entrance of Henry Cole State Park, off Steeley Road. This little worked prospect is located within the Franciscan Group. It is within the Hoover Valley Creek drainage which drains into Anderson Reservoir via Packwood Creek. The second is a copper prospect known as the Masson Ranch located within the Huntington Hollow tributary of Coyote Creek, just upstream from the confluence of Canada de los Osos. This prospect is also located in the Franciscan Group. Both of these are minor and should have no effect upon the watershed.

There are neither ongoing commercial rock quarrying nor gravel quarrying operations at this time within the watershed.

Housing developments are located along the southwest side of Anderson Reservoir. Most are sewered to a publically-owned treatment plant but some are not. In the past and to the present, certain accidental incidents of sewage spills into the reservoirs had been noted. Septic tank systems are also associated with the limited recreational developments on the west side of Coyote Reservoir.

A limnologic investigation at Anderson Reservoir was conducted with field studies being performed during the period October 1974 through September 1975 (McCune, William J. and Gloege, Isabel S., May 23, 1978). The study concluded current baseline limnologic conditions at Anderson Reservoir are generally good, as based on considerations of nitrogen, phosphorus, production of algae, dissolved oxygen, phytoplankton, and zooplankton levels. This is generally expected as the annual reservoir turnover percentage is high. A monitoring program was recommended in the final report.

An industrial development occurs in two small tributaries to the northern arm of Anderson Reservoir. The development is the Coyote Unit, Chemical Systems Division of United Technologies Corporation (UTC) and is located in Shingle Valley and in the adjacent valley referred to as Mixer Valley. The operations consist of the manufacturing and testing of solid fuel rocket propellent. The site is located within the Santa Clara formation. Volatile organic solvents have locally contaminated soils and groundwater. Though the Santa Clara formation is not considered to be water bearing in the mountainous and foothills area, it does contain meager amounts which at times may provide enough waters for local domestic needs. With remedial action activities implemented by UTC, the contamination is confined to the property itself. However, recent sampling (July 1998) indicated elevated levels of perchlorate (specifically ammonium perchlorate, an oxidizing ingredient in solid rocket fuel propellent) were detected dissolved in Mixer Creek and Las Animas Creek waters. The levels detected were 228 parts per billion (ppb) in Mixer Creek (on site) and 93.9 ppb in Las Animas Creek immediately downstream of the UTC property. No drinking water standards for perchlorate has been established. The State Department of Health Services has adopted an action level of 18 ppb. Under the oversight of the State Regional Water Resources Control Board, the discharger is to come up with a plan to prevent off-site flow of contaminants and to address the eventual cleanup to practicable levels. At present, the perchlorate levels are not suspecting to be impacting water supplies of Anderson Reservoir, due to the high amount of dilution as the contaminant residuals migrate downstream and into the reservoir.

Recreational motorized boating occurs at both Coyote and Anderson Reservoirs. Methyl tertiary-butyl ether (MTBE) and oil film are impacted into the reservoirs waters at trace levels. The District is monitoring MTBE levels within the reservoirs and, as a means of controlling its level, the District and County Parks and Recreation Department started to regulate motorized boating activities on these reservoirs.

STEVENS CREEK

Stevens Creek Reservoir watershed is located on the west side of Santa Clara Valley, on the northeastern slopes of the Santa Cruz Mountains. The dam is located downstream of the confluence of Stevens Creek and Swiss Creek. The watershed terrain is characterized by steep, moderately densely forested slopes (Saah, 1978). Elevation changes from highs over 2,200 feet above the North American Datum of 1927 (NAD 27) to the reservoir surface of approximately 540 feet NAD 27. The watershed drainage area is approximately 17.3 square miles. Annual rainfall is approximately 27.5 inches, with a 15-year minimum of 10.5 inches in 1976 and a 15-year maximum of 62 inches in 1983.

There are three primary inflows into the reservoir: Stevens Creek, Swiss Creek, and Firehouse Creek. Stevens Creek and Swiss Creek typically run all year. Firehouse Creek does not run all year and contributes mostly in the rainy season. Stevens Creek is supplemented by four main tributaries: Indian Creek, Bay Creek, Indian Cabin Creek, and Gold Mine Creek. There are numerous springs located on the southwest side of Monte Bello Ridge which feed the tributaries.

The uppermost areas of the Stevens Creek watershed is bisected by the northwesterly trending San Andreas fault which is located along Stevens Canyon. The southwest side of the San Andreas fault, up to the county line represented by a northwesterly ridge line, is underlain by Tertiary sedimentary formations with northwesterly trending slivers of Cretaceous sedimentary formations. The largest areas of the Tertiary sedimentary formations consist of the Vaqueros formation with small portions, in the southwestern corner of the watershed, of the Monterey formation.

On the northeast side of the San Andreas fault, most of the watershed is underlain by the Franciscan Group and its serpentine member with slivers of Tertiary sedimentary formations close to the fault. Significant landslides occurs upon these units.

The lowermost topographic areas of the watershed is underlain by the Santa Clara formation, upon which also occur some significant landslides. The areal distribution of the geologic units is shown on Figure _____.

The structural geology is dominated by the San Andreas fault and by the Berocal fault which parallels the San Andreas fault to the northeast. The folded beddings of the sedimentary formations strike northwesterly. The older formations are more deformed into tight folds and local faults while the younger formations are less pervasively deformed. The relatively young Santa Clara formation is gently folded, though some faults occur in it. Stevens Creek Dam is founded on tilted beds of conglomerate of the Santa Clara formation.

A sampling station upstream of the reservoir indicated a range of TDS from 171 to 401 mg/L and pH from 8.1 to 8.6 for a period from January 1996 to June 1997. Two complete mineral analyses indicated the waters to be a calcium bicarbonate and magnesium-calcium bicarbonate types. These mineral types are consistent with the geology of the watershed with calcium bicarbonate type suspected to predominate at times of high runoffs and magnesium-calcium bicarbonate at times of lower flows.

Water sampled from the reservoir, with data spanning a much longer period, indicated similar ranges of parameters. TDS ranged from 236 to 496 mg/L and pH from 8.1 to 8.5. Mineral type also ranged from calcium bicarbonate to magnesium-calcium bicarbonate. It is unusual that the streamflow parameters range did not vary much wider than the reservoir range as the mixing and storing of waters would have tended to average out the stream flow range. This lack of variance may be attributable to the small capacity of the reservoir and, hence, more closely reflect streamflow mineral quality characteristics.

There are no known active or inactive mining activities in the watershed. Gravel quarrying operations are still active in the area of Stevens Creek Dam and upstream on one of the northern tributaries close to the dam. These operations involved the quarry of gravels from the conglomerate of the Santa Clara formation.

Land use has been limited to some scattered residences and farming of orchards and vineyards, mostly upon the large ancient landslide adjacent and west of the reservoir. Large-scale ranching activities have been restricted due to the severe terrain. There occur limited recreational activities in the reservoir area and in the watershed, including a recreation camp. The limited amount of sampling of reservoir has not indicated any potential nutrient problem at this time.

LOS GATOS CREEK ABOVE LEXINGTON RESERVOIR

Lexington Reservoir watershed is located on the west side of Santa Clara Valley, on the eastern slopes of the Santa Cruz Mountains. The dam is located on Los Gatos Creek. The upper reach of the Los Gatos Creek drainage includes Williams Reservoir and Lake Elsman. The watershed terrain west of Los Gatos Creek is generally less steep than the east side. The watershed terrain east of Los Gatos Creek is characterized by steep, moderately densely forested slopes (Saah, 1978). Elevation changes from highs over 3,400 feet above the NAD 27 on the east and over 2,400 feet NAD 27 on the west to the reservoir surface of approximately 645 feet NAD 27. The peak of Mt. Thayer (3,483 feet NAD) is within the watershed. The watershed drainage area is approximately 37.5 square miles.

The west side of the Lexington Reservoir watershed contains Lake Ranch Reservoir in the upper reach of Beardsley Creek. The west side also has two small off-stream lakes, Lake Kittredge and Lake Couzzens operated by San Jose Water Company. Development is mainly concentrated along the Highway 17 corridor, south of Lexington Reservoir. Rainfall totals are determined from data collected by the District from 1952 through 1992. Average rainfall is 37.43 inches, with a minimum of 13.30 inches in 1976 and a maximum of 79.60 inches in 1983.

There are several inflows into the reservoir. The primary ones are Lime Kiln Creek and Soda Springs Creek. Hendrys Creek, Los Gatos Creek (with Lake Elsman), and Aldercroft Creek contribute water most of the year. Briggs Creek, Black Creek, and Beardsley Creek contribute water only part of the year during the wet season.

Just upstream of Lexington Reservoir, the San Andreas fault cuts northwesterly across the watershed. The upper reaches of the watershed on the southwestern side of the San Andreas fault to the crestline that divides Santa Clara County with Santa Cruz County occur beds of northwesterly trending Tertiary sedimentary formations. The northern portion is underlain by the Vaqueros formation and the southern by the Monterey formation.

A thin sliver of northwesterly trending Cretaceous sedimentary formations occurs along northeastern side of the San Andreas fault in the northern portion of the watershed. In the southern part, the Cretaceous sedimentary formation broadens as to encompass large areas of the upstream watershed. Lake Elsman is underlain by this unit.

Lexington Reservoir and areas to the east and northwest of the reservoir are underlain by the Franciscan Group and related serpentine unit.

Small areas along the stream channels and beneath the reservoir occur ribbons of Old Alluvium, deposited as stream channel deposits and have since been dissected by erosion and now have the appearance as terrace deposits. A geologic map of the watershed is presented as Figure _____.

The structural geology of the watershed is dominated by the northwesterly trending San Andreas fault. Numerous parallel and subparallel faults also occur, some of which may be considered to be active. One of the more significant of these is the Sargent-Berocal fault which parallels the San Andreas fault to the northeast. The general bedding of the sedimentary formations also trend northwesterly. Numerous old and young, large and small landslides occur within this drainage.

The mineral quality of the reservoir waters ranges from calcium bicarbonate to calcium-magnesium bicarbonate type. This is consistent with the geologic character of the watershed. The lesser amount of magnesium equivalents as compared to calcium compares with similar drainages where the watershed is underlain by a considerable lesser amount of Franciscan Group and its serpentine member. TDS ranged from 169 to 352 mg/L and the pH from 7.5 to 8.80.

Several insignificant mercury prospects occur within this Los Gatos Creek watershed. Perhaps the only significant metals prospect is the Hooker Creek copper prospect located at Aldercroft Heights. Mineralization occurs within the serpentine member. The limited mining activity continued intermittently from 1917 to 1929. A small production of gold and silver was reported in 1936 to 1938 and then since the prospect had been inactive. Because these mining activities are less than significant, they pose no adverse effect upon the overall water quality of the reservoir waters.

Quarrying activities have been in the form of limestone at two sites up the Lilm Kiln Canyon tributary of Lexington Reservoir. These are the Douglas Ranch and the Lyndon quarries. Small stone quarrying operations occurred at various locations within the watershed but perhaps most notably at the Alma Fire Station area. These quarries are inactive and generally pose little effect on the overall quality of reservoir waters.

A once active, very small oil field occurs 2½ miles upstream or south of Lenihan (Lexington) Dam in the Moody Gulch area. The oil field was discovered in 1879 and had its greatest production before 1912 and had produced intermittently to the 1950s, but by then it was producing only a couple of barrels per day. The producing zone was from a depth of about 1,200 feet, from Tertiary sedimentary formations, mainly from the San Lorenzo formation. Today, most of the wells are buried beneath the Highway 17 fill at Moody Gulch. Though the Moody Gulch oil field provides no effect upon the overall quality of Lexington Reservoir waters, oil fields can produce brines as waste which could have the potential to affect the quality of watershed discharges.

Of the reservoir watersheds in the county, Los Gatos Creek above Lexington and Vasona are the most highly developed with habitation and general use. Aldercroft Heights, Chemeketa Park, Holy City, Redwood Estates, and a development above Lexington Reservoir on the Montevina arm are clusters of development within the watershed above Lexington Reservoir. In addition, there are individual houses and estates outside the relatively densely-populated areas and also include schools and recreational camps. These developments have the potential to cause nutrient loading due to developments being on septic tanks. Short-term sediment yield from construction and longer-term yields from roads could also pose reservoir water quality problems. One housing area, upstream on the Montevina arm of Lexington Reservoir, is addressing the nutrient problem with the installation of a community leach field operated by the Lake Cayon Community Services District. This action was taken after determining that a number of septic tanks were failing in the area due to inadequate leach field conditions.

According to the analyses of reservoir waters, nutrient load doesn't appear to be a problem on the overall waters of the reservoir. This is probably because of the lush growth in the areas of developments which have a high rate of nutrient consumption and due to the high dilution and high seasonal turnover of waters within the reservoir. However, some problems have been noted in the Montevina arm of the reservoir, mainly due to bacterial contamination caused by nonpermitted recreational camping.

A certain amount of ranching and minor amounts of farming occur within the watershed. These would have the potential to further add to the nutrient and sediment loadings of the reservoir.

Logging and additional developments can provide additional threats due to short-term and long-term sediment yield and nutrient loading unless best management practices are observed in order to mitigate adverse effects to tolerable levels.

LOS GATOS CREEK FROM LEXINGTON RESERVOIR TO VASONA RESERVOIR

Vasona Reservoir watershed is located on the southwest side of Santa Clara Valley, on the eastern slopes of the Santa Cruz Mountains and in Los Gatos. Vasona Dam is located on Los Gatos Creek approximately 2 miles downstream (northeast) of the Lexington Reservoir dam. The watershed drainage area is approximately 6.46 square miles (Saah, 1978). The upper part of the watershed is located on the eastern slopes of Monte El Soreno and the northern slopes of St. Josephs Hill. The lower part of the watershed consists of the mainly flat Los Gatos area north of the upper part of the watershed. The lower part of the watershed are well developed and urbanized. The upper part is less urbanized in the steeper portions. Elevation changes from highs over 2,200 feet above NAD 27 on the south to the reservoir surface of less than 320 feet NAD 27. Rainfall totals are determined from data collected by the District from 1977 to 1992. Average rainfall is 17.46 inches, with a minimum of 8.00 inches in 1987 and a maximum of 36.3 inches in 1983.

Inflow into Vasona is mainly from Lexington Reservoir and smaller amounts from urban runoff through storm drains and surface runoff. There is also contribution from Trout Creek, which runs all year and empties into Los Gatos Creek. Almendra Creek contributes only during storm flash flooding.

The Los Gatos Creek watershed between Vasona Dam and Lexington Reservoir is a relatively small watershed with a little more than one-half its area in the mountains and foothills of the Santa Cruz Mountains and the remainder on the valley floor of Santa Clara Valley. The valley areas are highly developed as the Town of Los Gatos and the City of Monte Sereno.

The upper mountainous portion of the watershed is underlain by the Franciscan Group and related serpentine member while the lower foothills and terraces are underlain by the Santa Clara formation and old alluvium. The stream floodplain is underlain by young alluvium. Vasona Dam is founded on young and old alluvium units.

Numerous faults and shear zones occur in the mountainous areas and some of these cut the Santa Clara formation. Among the younger faults that cut the Santa Clara formation, their potential state of activity is unknown.

Sampling stations for this project have been established on Los Gatos Creek at Roberts Road and at Vasona Reservoir. Mineral quality at these two stations exhibited similar qualities. As expected waters of Vasona Reservoir reflect a water type similar to that of Lexington Reservoir, mostly a calcium bicarbonate type and ranges to a calcium-magnesium bicarbonate type at times of low summer and fall flows. TDS shows generally a narrow range from 171 to 317 mg/L and pH from 7.8 to 8.2. Since the capacity of Vasona Reservoir is small, water releases from Lexington Reservoir is just momentarily detained in Vasona Reservoir before passing through. However, as the flows from Lexington passes through urban areas, landscaped urban recreational parks, and Vasona Reservoir, itself a refuge for ducks, geese, and other birds, subtle differences in quality are noted from Lexington discharge to Vasona Reservoir. In most instances, the nitrate, total phosphorus, total organic carbon, dissolved organic carbon, and heavy metals content are slightly higher at Vasona as compared to Lexington waters, though these constituents content is still considered to be extremely low.

In the past, the young alluvium stream channel deposits have been quarried for sands and gravels. These operations are long over and should not pose water quality problems.

Several single old oil wells occur within the drainage upstream of Vasona Dam along the floodplains and terrace deposits. These have been capped and have long been out of operation. Oil shows may have been in the Tertiary Monterey formation which underlys the valley floor beneath the alluvium and the Santa Clara formation in this area. Past production had been extremely limited. No impact is estimated from the past oil production upon the overall water quality.

Future additional developments in the watershed is generally not expected as the relatively flat areas appear to be fully developed.

GUADALUPE CREEK

The Guadalupe Reservoir watershed is located on the southwest side of Santa Clara Valley, on the eastern slopes of the Santa Cruz Mountains. The Guadalupe Dam is located on Guadalupe Creek approximately 2 miles south of Almaden Valley area of San Jose. The watershed drainage area is approximately 6 square miles (Saah, 1978). Mt. Umunhum is within the watershed with an elevation of 3,486 feet NAD 27. The Guadalupe Reservoir spillway elevation is 614 feet NAD 27. The drainage area for the reservoir is characterized by steep, hilly terrain with moderately forested slopes with range grass and low bushes (Saah, 1978). The majority of the watershed is rural and undeveloped, with the exception of some mining operations to the south-southeast and an old military installation on the top of Mt. Umunhum. Rainfall totals are determined from data collected by the District from 1976 to 1992. Average rainfall is 22.62 inches, with a low of 7.90 inches in 1976 and a high of 31.80 inches in 1992.

The primary inflows into the reservoir are Guadalupe Creek which runs all year at a low volume, Rincon Creek which confluences with Guadalupe Creek and can run all year, and Los Capitancillos Creek. Los Capitancillos Creek contributes water mainly during flooding events and is considered "flashy." Rincon Creek, although it can flow all year, is also considered to be "flashy."

Nearly all the area of the Guadalupe Creek watershed above Guadalupe Reservoir is underlain by the Franciscan Group and its related serpentine unit. Only a small portion in the southwestern edge is underlain by Cretaceous sedimentary formations and a small sliver of Tertiary sedimentary formations occur along the Berocal fault, just upstream of the reservoir. These formations and the Berocal fault trend in a northwesterly direction. Bounding the southwestern side of the reservoir, a wide band of sheared and contorted melange of the Franciscan formation trends northwesterly. This zone has also been referred to as the Ben Trovato fault zone. The Berocal fault joins the Ben Trovato fault zone southwest of the reservoir. Numerous large and small landslides occur along the Ben Trovato fault zone and descends into Guadalupe Creek and its tributary, Los Capitancillos Creek. The geology of the watershed is presented on Figure _____.

Two water quality sampling stations were established from which sampling occurred monthly from December 1995 through June 1997. These are the Hicks Road station on Guadalupe Creek upstream of the reservoir and the Guadalupe Dam station. Mineral quality at the two stations were remarkably similar even though on averaging through mixing is expected in the reservoir waters. However, the reservoir is relatively small and the effects of mixing is not apparent.

The limited number of complete mineral analyses available indicated the waters to be a consistent calcium-magnesium bicarbonate type. It is surprising that the magnesium equivalent percentage is not higher with the watershed drainage being almost entirely underlain by the Franciscan Group and its related serpentine member. TDS ranged from 132 to 396 mg/L and pH from 7.6 to 8.8 spanning both sampling stations. Mercury content was consistently lower than 0.2 micrograms per liter (ug/L). Though nitrate content was extremely low, averaging 0.32 mg/L in the upstream station at Hicks Road, it was even lower in the reservoir due to denitrification process in the reservoir. The total organic carbon and dissolved organic carbon were also low but is slightly higher in the reservoir than at the upstream station.

Adjacent to the north and east side of the reservoir are old mine workings of the San Antonio Mine and the Enriqueta Mine, both old mercury mines. Just upstream of the reservoir are the old workings of the Providencia Mine and further upstream on the Los Capitancillos tributary occur the drainage that encompass a portion of the drainage from the American Mine and the New Almaden Mine atop Mine Hill. These are also mercury mines. Downstream of the reservoir occur the San Mateo Mine on the north side of Guadalupe Creek at the toe of the dam and the Senator Mine a little further downstream, again both mercury mines. All of these mines are no longer active and a large portion of the areas containing the mines, including Mine Hill, are now included as part of the Almaden Quicksilver County Park, a general recreation area.

Though metallic mercury does not present a problem by itself due to its general insolubility, a minute amount methalates through biochemical means under anoxic conditions. Methalated mercury is highly poisonous. The very low concentrations (generally immeasurable) of methalated mercury that is related to mines runoff have the potential to bioaccumulate up the food chain from algae uptake in the reservoir up through the flesh of fish. Signs are posted at the affected reservoirs and along the streams below the reservoirs warning anglers not to consume the catch. Mitigation have been implemented at the Almaden Quicksilver County Park to address the mercury problem. Mitigations included the capping of contaminated areas and erosion controls of the mine waste piles. This case was on the State Superfund list.

One oil exploration well (Trigonia 5) was installed below Mt. Umunhum, just off Guadalupe Creek upstream of the reservoir. Little is known about this well other than it being a nonproducer and is believed to have no effect upon the quality of surface waters.

The watershed above the reservoir has generally not been developed except for the now inactive mercury mining activities and the U.S. Airforce radar station atop Mt. Umunhum which is also inactive and has been dismantled. An old fuel leak spill was noted at the radar station. This is expected to have no affect on the overall quality of surface waters.

Limited ranching activities within the watershed could have the potential to impact nutrient and sediment loading from the watershed should such activities are increased to a high level.

ALAMITOS CREEK

The Alamitos Creek watershed above Almaden Reservoir is located on the southwest side of Santa Clara Valley, on the eastern slopes of the Santa Cruz Mountains. Almaden Dam is located approximately 1 mile upstream (southwest) of the community of New Almaden. The watershed drainage area is approximately 12.0 square miles (Saah, 1978). Elevations range from highs above 3,400 feet NAD 27 to the crest of the dam of 615 feet NAD 27. The drainage area for the reservoir is characterized by hilly terrain covered with range grass, low bushes, and trees. Slopes are typically greater than 30 percent and a high proportion of the slopes near the top of the watershed are greater than 70 percent (EOA, 1989).

Precipitation data for the Almaden watershed are summarized below:

Summary Precipitation Data for the Almaden Watershed

Gauge Station (Period of Record)	Average Annual Precipitation (inches)	Maximum Annual Precipitation (inches)	Minimum Annual Precipitation (inches)
Mt. Umunhum (10/68 to 06/95)	41.54	86.6 in 1983	13.66 in 1994
Loma Prieta (07/61 to 06/95)	45.96	91.1 in 1983	20.0 in 1976
Twin Creeks (10/70 to 06/95)	31.19	62.6 in 1983	11.0 in 1976

Inflows into Almaden Reservoir include Larabee Gulch Creek, Barret Canyon Creek, Herbert Creek, and Jacques Gulch Creek. Barret Canyon Creek and Herbert Creek flow all year and are two branches of Almalitos Creek. Jacques Gulch Creek flows most of the year and Larabee Gulch Creek contributes during high peak flows, then drops off quickly.

About two-thirds of the Alamitos Creek drainage above Almaden Reservoir is underlain by the Franciscan Group and related serpentine member, including the reservoir area. The uppermost one-third, in the southwestern portion of the drainage, is underlain by Cretaceous sedimentary formations.

A northwesterly trending wide band of Franciscan melange zone cuts across the reservoir. This zone has also been referred to as the Ben Trovato fault zone. Just upstream of the Ben Trovato fault zone also passes the northwesterly trending Berocal fault which eventually joins the Ben Trovato fault farther to the northwest. Another northwesterly fault also passes the upper end of the watershed, separating the Franciscan Group on the northeast and the Cretaceous sedimentary formations on the southwest. This fault is referred to as the Soda Springs fault and a splinter of this fault to the west is referred to as the Sierra Azul fault. The activity of these faults mentioned is uncertain but generally suspected to be inactive. The geology of the watershed is presented in Figure _____.

The now inactive New Almaden Mine atop Mine Hill is located northwest of Almaden Reservoir and a portion of the mine area is located within the reservoir watershed. Other portions of the mine and the old reduction works occur in the drainage downstream of the reservoir. The reduction work was located at Hacienda site along Alamitos Creek and has long been dismantled.

In addition to the sampling station at Almaden Reservoir, two other stations were established upstream of the reservoir. These include station TC6 located upstream of the western end of the reservoir, just downstream of the confluence of the two major tributaries, Herbert Creek and Barret Canyon Creek, and a station at the mouth of Jacques Gulch, a tributary to the reservoir from the north. Old mine waste materials have been washed down Jacques Gulch from Mine Hill. The station on the reservoir and station TC6 were sampled monthly from December 1995 to June 1997; Jacques Gulch was sampled from January 1996 to March 1997.

Waters at station TC6 ranged from a calcium bicarbonate to a calcium-magnesium bicarbonate mineral type with TDS ranging from 138 to 265 mg/L and pH from 8.1 to 8.8. These are consistent with the geologic terrain of the watershed. Though nitrate concentrations were low, a consistent showing was noted and which average 0.22 mg/L. The source of nitrate could be from the recreational and rural housings upstream of the station. Mercury content tested to be less than 0.2 ug/L.

Waters of Jacques Gulch also ranged from a calcium bicarbonate to a calcium-magnesium bicarbonate mineral type. TDS ranged from 160 to 310 mg/L and pH from 7.9 to 8.3. The TDS was generally higher than at station TC6. This can be expected as the drainage area of Jacques Gulch is smaller and as a consequence, it generally would contain a higher ratio of groundwater discharges to surface runoffs more of the time. Nitrate content is generally lower than at station TC6. Mercury content was less than 0.2 ug/L. It is suspected that the problem of the accumulated mercury in the flesh of fishes has its significant part of its origin from runoffs of mercury mining activities at the New Almaden Mines, largely via Jacques Gulch.

The reservoir waters ranged from a calcium bicarbonate type to a more often calcium-magnesium bicarbonate type. These are consistent with the geology of the watershed and with the analyses from the other two upstream stations. TDS ranged from 155 to 236 mg/L during the study sampling period; however, random earlier samplings in 1974 and 1975 indicated a higher range of TDS from 220 to 452 mg/L. These earlier sampling events may have been during seasonal periods of lower rainfall and runoff. pH ranged from 7.8 to 8.7. Nitrate content was significantly lower than at stations TC6 and Jacques Gulch, indicating denitrification to be occurring in the reservoir. Total organic carbon and dissolved organic carbon ranged from 1.27 to 3.04 mg/L and 1.43 to 3.13 mg/L, respectively. Though these are low, they are higher than that noted at the two upstream sampling stations.

Mercury content was consistently less than 0.2 ug/L, well within the acceptable range for drinking and other beneficial uses. However, because of the erosional washing of mine waste from the New Almaden Mine into the reservoir allows a minute amount of mercury to become methalated to methyl- and dimethyl mercury by biochemical activity under anoxic conditions. Methalated mercury is highly poisonous. The minute amounts that converts in the reservoir allow it to move up the food chain from algae to the flesh of fish. This could represent a threat to those who consumes the fish on a consistent basis over their life span. Though the mercury content in reservoir and stream waters remained consistently below 0.2 ug/L, the relative concentration in the flesh rises as the fish grows due to bioaccummulation. Almaden Quicksilver County Park became listed as a State Superfund case that limited park activities only to hiking and horseback riding, rather than for general use until the contamination is remediated. Signs are posted around the Almaden and Guadalupe Reservoirs and along the stream downstream of these facilities, warning fishermen to not consume their catch. A mitigation plan had been completed, to cap the old Hacienda reduction work site downstream of Almaden Reservoir and to control erosion of mine waste piles in the Mine Hill area of the park. These were completed in 1998. However, the signs regarding the warning against the consumption of fish will still remain as the problems in the reservoir will continue to persist. Since the capacity of Almaden Reservoir is small relative to its relatively large size drainage area, the District had construction the Almaden-Calero Canal to divert excess waters to Calero Reservoir. As a consequence, warning signs against fish consumption were also posted around Calero Reservoir and along Arroyo Calero downstream of the dam.

Other types of development in the watershed is limited except for recreation and ranching. The effects of nutrient and sediment loading from recreation and ranching activities would vary with the intensity of these uses upon the watershed, which is generally low at this time.

ARROYO CALERO

The Arroyo Calero watershed above Calero Reservoir consists of about 7 square miles of rolling hills covered with a mix of grassland and oak savannah, located on the south side of Santa Clara Valley in the Santa Cruz Mountains, to the northeast of the Almaden Reservoir. The dam is located on Arroyo Calero at the north end of the reservoir, adjacent to McKean Road. There is also an auxiliary dam east of the main dam near McKean Road on the north side of the reservoir. Both dams have crest elevations at 490 feet (EOA, 1989).

The District maintains one rain gage in this watershed, Station 128-1513. The mean annual precipitation measured from September 1978 through June 1995 was 23.35 inches, the low was 10.5 inches for the rain year ending June 30, 1987, and the high was 49.5 inches for the rain year ending June 30, 1983.

The inflows into Calero include Arroyo Calero and Cherry Creek, which flow most of the year at low volume. Cow Creek also contributes part of the year. The Almaden-Calero Canal transfers water from Almaden Reservoir to Calero Reservoir as Almaden Reservoir fills. Calero has approximately five times the storage capacity of Almaden. The canal is 4 miles long and has a capacity of 125 cubic feet per second. The long-term annual average runoff from Calero and Almaden watersheds combined is 19,400 acre-feet per year (EOA, 1989). The canal also contributes natural inflow in addition to the Almaden Reservoir water. Imported water of the San ~~Luis~~ Felipe Project from San Luis Reservoir via the Cross Valley Pipeline can either be delivered into Calero Reservoir or be piped past it to the Almaden Pipeline.

The reservoir and a large portion of the drainage to the south of the reservoir are included within the Calero Reservoir County Park.

The Arroyo Calero drainage area above Calero Reservoir is underlain by the Franciscan Group and its serpentine member except for areas of thin alluvium along the tributaries that enters the reservoir from the southeast. Several notable inactive, northwesterly trending faults cut the drainage area. One such fault passes beneath Calero Dam and another unnamed fault passes to the west and the two faults join to the southeast in the Llagas Creek drainage. Several large old landslides and numerous smaller, young and old landslides occur along the Cherry Canyon tributary to the southwest side of the reservoir and upstream. The geology of the watershed is presented in Figure _____.

A sampling station was established for this study on Pine Tree Canyon, where Arroyo Calero enters the reservoir at its southeastern edge. This station is referred to as Cal Golf and is located where McKean Road crosses the stream east of the reservoir. The station was sampled on a monthly basis from January 1996 through May 1996 and from December 1996 through April 1997, due to intermittent seasonal flows. Reservoir water was sampled at the outlet vault on an interim basis by the California Department of Water Resources with records spanning a period from October 1974 through August 1975.

Analyses of waters sampled at the Cal Golf station indicated the waters to be a calcium-magnesium bicarbonate type with TDS ranging from 285 to 360 mg/L and pH from 7.7 to 8.7. This mineral type water is somewhat consistent with the geologic conditions of the watershed but normally a higher magnesium equivalent percentage would be expected from the Franciscan Group and serpentine terrain.

The TDS is slightly higher than expected, probably due to the smaller watershed. On occasions, relatively high spikes of nitrate content is reported, up to 12.8 mg/L; chloride content, up to 40 mg/L; total organic carbon, up to 10.20 mg/L; and dissolved organic carbon, up to 11.10 mg/L. These high spikes are well above background. Bacterial levels at this station also reported relatively high spikes at times. These unusually high spikes are probably the result of ranching activities upstream on this relatively low, intermittent flow tributary. Because of these periodic degradation of flows, reservoir waters would have to be checked for cryptosporidium and giardia, in addition to coliform.

A new golf course is under construction just upstream of the Cal Golf station. Operation of the golf course would have the potential to increase nutrient loading to the reservoir.

Reservoir water represents a mix of indigenous waters from within the watershed and in addition to waters diverted into the reservoir from Almaden Reservoir via the Almaden-Calero Canal. At times, imported waters from the San Felipe Project could be discharged into the reservoir. Hence, the reflection of reservoir water quality could vary with the scheme of reservoir operation.

Mineral analyses of waters of 1974 to 1975 (prior to San Felipe importation) from the reservoir outlet vault were only partially analyzed of the mineral constituents and consequently the mineral quality could not be typed. The relative salinity of the waters were only given in specific electrical conductance which ranged from 285 to 360 microSiemens per centimeter at 25 degrees centigrade. pH ranged from 7.7 to 8.7. Mercury content was not determined. Today, the mix of waters in the reservoir should produce a calcium bicarbonate to a calcium-magnesium type water, a lot like the mineral quality of Almaden Reservoir water.

Although the Arroyo Calero watershed above Calero Reservoir is devoid of mercury mining or any other type of mining activity, warning signs against the consumption of fish from within the reservoir and Arroyo Calero downstream of the dam are posted. This represents the warning extension of Almaden Reservoir from which water is diverted.

Development of the western and southern portion of the watershed is limited as the western portion is topographically rugged and the southern portion had been annexed into the Calero Reservoir County Park. The flatter eastern portion of the watershed is undergoing the development of the aforementioned golf course. The remaining flatter areas in the area may also be subject to further developments, including the construction of a larger capacity road to the present road. These developments are expected to add nutrient and sediment loadings to the reservoir.

A small portion adjacent to the southern end of the reservoir was in Orchards. Today, a horse ranch and stables have been developed. A levee had to be built to keep a portion of the operation dry during high reservoir stage. The construction of this levee leaves a pocket of reverse drainage. During times of high rainfall, drainage waters would accumulate in the pocket and would begin to flood out the horse ranching operation. A drainage pump had to be installed that pumps accumulated drainage over the levee into Calero Reservoir. Runoff from another horse ranch northeast of the reservoir also enters the reservoir. Discharges from both sources are monitored when flowing and results indicated elevated levels of bacteria and nutrients. Eutrophication of the reservoir is not expected as the reservoir has a high percentage of annual turnover.

Recreational motorized boating occurs with this reservoir. MTBE and oil-based films are imparted into the reservoir at trace levels. The District is monitoring MTBE levels within the reservoir and, as a means of controlling its level, the District and the County Parks and Recreation Department started to regulate motorized boating activities on the reservoir.

As noted in the Regional Geology section, waters draining from Franciscan and serpentine terrain can be expected to contain minute amounts of asbestos fibers.

LLAGAS CREEK

Llagas Creek watershed above Chesbro Reservoir is located on the southwest side of the Llagas Basin, on the eastern slopes of the Santa Cruz Mountains. The dam is located on Llagas Creek approximately 1 mile upstream (northwest) of Paradise Valley. The watershed terrain is characterized by moderately sloping, light to moderately dense forested slopes, with steeper terrain in the upper reaches of the Llagas Creek watershed. Elevation changes from a high of 3,562 feet NAD 27 for Mt. Chual to the spillway elevation of 525 feet NAD 27. The watershed drainage area is approximately 39 square miles. The area is mostly rural with some development along Uvas Road and Willow Springs Road. Rainfall totals are assumed to be similar to the totals for Uvas Reservoir Watershed. Rainfall totals are determined from data collected by the District from 1962 to 1992. Average rainfall is 27.92 inches, with a minimum of 8.50 inches in 1976 and a maximum of 57.00 inches in 1983.

There are several inflows into Chesbro Reservoir. The primary inflows are Llagas Creek and Canada Garcia Creek which both flow most of the year. Quail Canyon Creek and Willow Springs Creek contribute during high precipitation events and are considered to be "flashy."

The amount of water contributed by each creek is unknown. The creeks are not gauged unless there are downstream riparian water rights. When there are riparian water rights, the streams are gauged during the summer months. During storm events, the change in reservoir storage is noted.

The Llagas Creek watershed above Chesbro Reservoir is largely underlain by the Franciscan Group and related serpentine intrusions. The uppermost reaches of the watershed to the summit ridge are underlain by northwesterly trending Cretaceous sedimentary formations and by Tertiary sedimentary formations, mainly the Monterey formation. The bottom areas of the somewhat broad mountain valley along the course of Llagas Creek upstream of the reservoir are underlain by deposits of old alluvium, atop the Franciscan Group and serpentine.

Numerous northwesterly trending faults cut the watershed, including the possibly active Sargent fault and Berocal fault in the upper watershed. The northwesterly trending Ben Trovato fault zone cuts upstream of the reservoir and the also inactive, northwesterly trending Calero fault cuts through the reservoir. The activity of this fault is not known.

A sampling station for this study was established at Chesbro Reservoir. Sampling results on a monthly basis are available from December 1995 through July 1997. An individual sampling result at a location downstream was also noted in California State Department of Water Resources Bulletin 130-75, February 1997.

Results of reservoir sampling indicated the waters to be mostly a magnesium-calcium bicarbonate type and changing occasionally to a magnesium bicarbonate type or a calcium bicarbonate type. These mineral water types are consistent with the geology of the watershed. The variability might be accounted for by the nature of runoff and effluent groundwater into the streams. TDS ranged from 145 to 262 mg/L and pH ranged from 7.60 to 8.90.

The single analysis taken downstream of the dam but above the diversion from Uvas Reservoir in April of 1975 indicated the waters to be a magnesium-calcium bicarbonate type with a TDS of 201 and a pH of 7.6. This is consistent with the more recent analyses discussed above.

There occurs limited residential houses on the steep slopes on the south side of the reservoir high above the waterline and a few older residences occurring near the lake shoreline on the southwestern portion of the reservoir. Also, some ranching along with some small farms occur in the stream valleys. Recreational activities occur mostly along the northern part of the reservoir.

There is a distinct possibility that development can occur in the broad, flat stream valley areas and up along the gentle side slopes of the lower drainage areas above the reservoir. As climatic conditions are drier here than, for instance, the Lexington basin, soil development would tend to be shallower and there occurs a less profuse growth cover. These factors would limit the area for use as high-density developments relying on septic tanks and leach fields, as the limited presence and depth of soils would also limit the capacity to absorb and treat the discharges and there would be lesser uptake of the nutrients by the natural vegetative cover. As a consequence, high-density developments would impart a high nutrient loading onto the streams and reservoir. Their construction would also place a high sediment loading and turbidity on a short-term basis.

UVAS CREEK

The Uvas Creek watershed above Uvas Reservoir is located on the southwest side of the Llagas Basin, on the eastern slopes of the Santa Cruz Mountains. The dam is located on Uvas Creek approximately 4 miles southwest of Morgan Hill. The watershed terrain is characterized by moderately sloping, light to moderately dense forested slopes, with steeper terrain in the upper Uvas Creek watershed. Elevation changes from a high of 3,786 feet NAD 27 for Loma Prieta to the reservoir surface of less than 480 feet NAD 27. The watershed drainage area is approximately 34 square miles and contains Nibbs Knob with an elevation of 2,694 feet NAD 27. The area is mostly rural with some development along Uvas Road and Croy Road. There are small reservoirs located in Hay Canyon. Several small reservoirs or ponds are located in the floodplains of Uvas Creek and Little Uvas Creek. Rainfall totals are determined from data collected by the District from 1962 to 1992. Average rainfall is 27.92 inches, with a minimum of 8.50 inches in 1976 and a maximum of 57.00 inches in 1983.

There are several inflows into Uvas Reservoir. Moving clockwise from Uvas Dam, they are Heninger Creek, Eastman Canyon Creek, Sycamore Creek, Wallace Creek, Little Uvas Creek, Uvas Creek, Hay Canyon Creek, and Oak Canyon Creek. Only Uvas Creek runs all year long.

The upper one-half of the watershed, extending to the dividing ridge line and which occupies the topographical rugged western portion of the drainage, is underlain by Cretaceous sedimentary formations and by Tertiary sedimentary formations, the tertiary unit mostly by the Monterey formation. These bedded units trend northwesterly. The east one-half of the area, which includes the lower watershed areas and including the reservoir, is underlain by the Franciscan Group and related serpentine unit. The broad stream valleys upstream of the reservoir are overlain with young alluvium atop the Franciscan Group. The upper elevated watershed is cut by the possibly active, northwesterly trending Sargent fault. The middle of the watershed paralleling the Sargent is the Ben Trovato fault zone, whose activity is uncertain. Numerous other smaller inactive faults cut the drainage.

For this study, three sampling stations have been designated and were sampled on a monthly basis. These are designated Uvas Tributary 1 which carries records from January 1996 through May 1997, Uvas Tributary 2 which carries records from January 1996 through June 1997 and at Uvas Dam, which carries records from December 1995 through November 1997.

Uvas Tributary 1 station is located on Little Uvas Creek, a main tributary into Uvas Creek from the north. Its interim watershed is underlain by the Franciscan Group and serpentine. Analyses indicate the waters of Little Uvas Creek to be a magnesium-calcium bicarbonate with TDS ranging from 137 to 339 mg/L and pH from 7.3 to 8.5. These are consistent with the geology of the watershed. Magnesium equivalent is expected to be the dominant cation from the Franciscan Group and serpentine. Most of the time, nitrate content is less than 0.05 mg/L but at times during the fall and winter months, nitrate content may be significantly higher, ranging up to 6.34 mg/L in the December 1996 sample. The higher nitrate content in the stream might be the greater influence of groundwater discharges to the stream. The nitrate content might be imparted to the groundwater from septic tanks from the rural community upstream.

Uvas Tributary 2 station is located on Uvas Creek upstream of the confluence of Little Uvas Creek. This watershed is underlain predominantly by sedimentary beds of Cretaceous and Tertiary formations.

Analyses indicated the waters to be a calcium bicarbonate type with TDS ranging from 112 to 255 mg/L and pH from 7.4 to 8.4. These are consistent with the geologic conditions. It is expected that calcium equivalent would predominate over the other cations from runoff of the Cretaceous and Tertiary sedimentary formations. Just as on the Little Uvas Creek tributary, nitrate content were at times elevated during fall and early winter months but the nitrate highs at Tributary 2 station were significantly lower, the highest ranging up to 1.02 mg/L, but in March 1996.

Reservoir water is expected to be predominated by a mix of waters passing Uvas Tributary Stations 1 and 2, a greater volume from Station 2. Uvas Reservoir sampling station analyses indicated the waters be a calcium-magnesium bicarbonate type with an occasional excursion to a magnesium-calcium bicarbonate type, which reflects a mix of the waters from Tributaries 1 and 2 stations. TDS ranged from 132 to 249 mg/L and pH from 7.4 to 8.7. The mixed reservoir waters showed a consistent lower levels of nitrate content than at the two upper stations, ranging from less than 0.5 to 1.18 mg/L. This could be accounted for by denitrification within the reservoir.

The watershed is devoid of mineral prospects or quarrying operations. The sand and gravel quarries along Uvas Creek all occurred downstream of Uvas Reservoir. At present, land development is limited to ranching and recreational activities, the latter particularly at Uvas Reservoir. One small housing development occurs with the Little Uvas Creek drainage on relatively steep slopes. During its construction in the early 1970s, short-term erosion and sediment yields were severe following construction. The present performance of their septic tank and leach field systems are unknown as to have the adequate conditions to fully treat septic wastes.

There is a distinct possibility that development will occur in the broad, flat stream valley areas and up along the gentle side slopes of the lower drainage, upstream of the reservoir, and in the confluence area of Little Uvas Creek into Uvas Creek. As also noted for the Llagas Creek watershed above Chesbro Reservoir, climatic conditions at these areas of the lower watershed are drier than, for instance, the Lexington basin, and as a consequence soil development are shallower and also contain less growth cover. These factors would limit the land use for a high-density development on septic tanks. Such high-density developments would tend to place additional nutrient loading on the stream and reservoir, in addition to that already being placed by ranching. They would also impart siltation and turbidity on a short-term basis.

BIBLIOGRAPHY

Bailey, Edgar H. and Donald L. Everhart, 1964, Geology and Quicksilver Deposits of the New Almaden District, Santa Clara County, California, U.S. Geological Survey Professional Paper 360.

Berkstresser, Jr., C.F., March 4, 1968, Data for Springs in the Southern Coast, Transverse, and Peninsular Ranges of California, U.S. Geological Survey Open-File Report, Menlo Park, California.

California State Department of Conservation, Division of Mines and Geology, 1998, Map of Santa Clara County Showing Mines, Prospects, and Watersheds, Preliminary, Subject to Revision.

California State Department of Water Resources, February 1977, Bulletin No. 130-75, Hydrologic Data: 1975, Volume III: Central Coastal Area, Sacramento, California..

__________________________, May 1988, Bulletin No. 130-85, Hydrologic Data, 1985, Volume III, Central Coastal Area, Sacramento, California.

California State Water Resources Board, June 1955, Bulletin No. 7, Santa Clara Investigation.

Churchill, Ron, November/December 1997, "Radon Mapping, Santa Barbara and Ventura Counties," California Geology, Volume 50, No. 6, pages 167-177.

Clifton, Daphne G. and Isabel A. Gloege, 1987, Water Quality of Calero Reservoir, Santa Clara County, California, 1981-83, U.S. Geological Survey Water—Resources Investigations Report 86-4105, Prepared in Cooperation With Santa Clara Valley Water District.

Davis, Fenelon F. and Charles W. Jennings, April 1954, "Mines and Mineral Resources of Santa Clara County, California, California Journal of Mines and Geology, Volume 50, No. 2, pages320-430.

Davis, G.H., Circa 1950s, Geologic Control of Mineral Composition of Stream Waters of the Eastern Slope of the Southern Coast Ranges, California, U.S. Geological Survey Open-File Report, Sacramento, California.

Dillon, P.J. and L.A. Molot, November 1997, "Effects of Landscape Form on Export of Dissolved Organic Carbon, Iron, and Phosphorous From Forested Stream Catchments," Water Resources Research, Volume 33, No. 11, pages 2591-2600.

EOA, Inc. (Eisenberg, Olivieri and Associates), December 1989, Almaden, Calero, Anderson/Coyote Watershed Management Plan. Report to the Santa Clara Valley Water District, Unpublished.

Hem, John D., 1959, Study and Interpretation of Chemical Characteristics of Natural Water, U.S. Geological Survey Water—Supply Paper 1473.

Hilton, Richard P., January/February 1997, "A Field Trip Transect of the Northern Sierra Via Interstate Highway 80, Rocklin to Donner Pass," California Geology, Volume 50, No. 1, pages 18-28.

Jordan, Thomas E., et al., November 1997, "Relating Nutrient Discharges from Watersheds to Land Use and Streamflow Variability," Water Resources Research, Volume 33, No. 11, pages 2579-2590.

McCune, William J., and Isabel S. Gloege, May 23, 1978, Anderson Reservoir Limnologic Investigation, California State Department of Water Resources, Central District, Sacramento, California.

Natural Science Foundation, 1973, "Trace Elements in Water: Origin, Fate and Control: I. Mercury, Planning and Exploratory Grant GI-32943, Stanford University, California.

Rogers, Thomas H., and John W. Williams, 1974, Potential Seismic Hazards in Santa Clara County, California, California State Division of Mines Special Report 107.

Saah, A.D., July 1978, Santa Clara Valley Water District Hydrology, Documentation for the Central Flood Control Zone, Unpublished.

Seward, Terry, April 1998, Mines Report, San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Sylvester, Marc A., 1986, Water Quality and Flow of Streams in Santa Clara Valley, Santa Clara County, California, 1979-81, U.S. Geological Survey Water—Resources Investigations Report 84-4196, Prepared in Cooperation With the Santa Clara Valley Water District, Sacramento, California.

Thomas Reid Associates, December 1990, Gilroy Hot Springs Resort Project, Draft Environmental Impact Report, Prepared for Santa Clara County, Palo Alto, California.

U.S. Geological Survey, 1970, Mercury in the Environment, U.S. Geological Survey Professional Paper 713.

Wakabayashi, John, 1966, Cool Under Pressure: An Exploration of High P/T Metamorphosis, The Franciscan Complex of the San Francisco Bay Area, AEG—S.F. Section Spring Field Trip, 1996.

Waring, Gerald, A., 1915, Springs of California, U.S. Geological Survey Water—Supply Paper 338.